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(56) Documents cited

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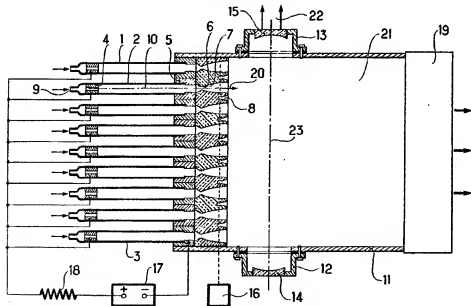
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(58) Field of search

H1C

(54) **A method of generating a 2.71 micron wavelength laser beam**

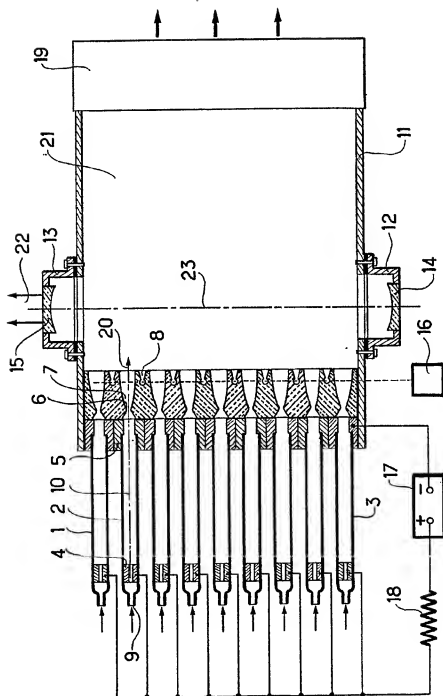
(57) The method consists successively of setting up an electric discharge in a hydrogen gas, expanding the gas in nozzles (7), injecting gaseous hydrobromic acid at the outlet of the nozzles and, making the expanded gas mixed with hydrobromic acid pass through an optical resonant cavity (14,15). The method is used to produce lasers beams for space applications.



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SPECIFICATION

A method of generating a 2.71 micron wavelength laser beam

5 The present invention relates to a method of generating a 2.71 micron wavelength laser beam. 5

BACKGROUND OF THE INVENTION

A known method of generating a 2.71 micron wavelength laser beam is described in the American article "Production of population inversions among the electronic states of atomic species by processes of intermolecular $V \leftrightarrow E$ energy transfer" by J.A. Blauer and G.D. Hager on pages 105 to 111 of the work "Electronic transition lasers" (J.I. Steinfeld), published by MIT Press in 1976. 10

In this method, a gaseous mixture which includes molecular hydrogen and argon is shock heated so as to raise the temperature of the mixture to above 5000°K and to form atomic hydrogen therein. The compressed mixture is then expanded by passing it through a nozzle and gaseous hydrobromic acid is injected in the gas flow which leaves the nozzle. The hydrobromic acid reacts on the atomic bromine at quantum level $^2P_{1/2}$. The molecular hydrogen excitation energy is then transferred to the bromine so as to make the bromine atoms change from the $^2P_{3/2}$ state to the excited $^2P_{1/2}$ state. The gas which contained the excited bromine is passed through an optical resonant cavity. 15

In principle, this method makes it possible to generate a 2.71 micron wavelength laser pulse by compressing the gaseous mixture but in practice it gives unsatisfactory and non-repetitive results. Further, it does not make it possible to obtain a continuous laser beam. 20

Preferred implementations of the present invention provide reliable methods of generating a 2.71 micron wavelength laser beam suitable for producing, on an industrial scale, a laser generator capable of generating such a beam. 25

SUMMARY OF THE INVENTION

The present invention provides a method of generating a laser beam with a wavelength of 30 2.71 microns, said method consisting in:

—forming hydrogen atoms in an initial gas which includes molecular hydrogen by setting up a high tension electric discharge therein, said discharge also producing vibrationally excited molecular hydrogen;

35 —expanding the gas which contains the hydrogen atoms by passing it through the nozzles at supersonic speed;

—injecting gaseous hydrobromic acid at the outlet of the nozzles in the gas flow direction, said acid reacting with the atomic hydrogen to form bromine atoms at quantum level $^2P_{1/2}$ together with vibrationally excited molecular hydrogen in addition to that formed by the electric discharge, thereby increasing the quantity of excited molecular hydrogen which then transfers its 40 excitation energy to the bromine so as to excite the bromine atoms at level $^2P_{1/2}$; and

—making the gas which leaves the nozzles and which contains bromine atoms at level $^2P_{1/2}$ pass through an optical resonant cavity perpendicularly to the axis of the cavity to obtain a continuous laser beam with a wavelength of 2.71 microns at the output of the cavity. 40

Thus the improvement of the present invention lies in the vibrationally excited molecular hydrogen produced by the electric discharge in addition to the hydrogen atoms. This provides a greater quantity of excited hydrogen molecules to transfer their energy to the bromine at quantum level $^2P_{3/2}$ and facilitates continuous laser beam production in the optical cavity. 45

BRIEF DESCRIPTION OF THE DRAWING

50 A particular embodiment of the present invention is described hereinbelow by way of example with reference to the accompanying drawing in which the sole figure illustrates a longitudinal cross-section of a laser emitter which is capable of bringing the method of the invention into effect. 50

DESCRIPTION OF THE PREFERRED EMBODIMENT 55

In the Figure, a plurality of cylindrical insulating tubes such as 1, 2 and 3 which are identical and parallel to one another have respective inlets 9 that lie in a plane perpendicular to the axial direction of the tubes.

A coaxial annular electrode 4 is disposed inside each tube at its inlet 9 end. Another coaxial 60 annular electrode 5 is disposed at the outlet of each tube. 60

The outlets of the cylindrical tubes are connected to a set of nozzles 7. Injectors 8 are placed downstream from constrictions 6 in the nozzles. Each injector 8 can be disposed e.g. inside a wall which is common to two consecutive nozzles so that the injection axis points in the gas flow direction 20 in the nozzles. The injectors 8 are supplied with gaseous hydrobromic acid via 65 passages which are not illustrated in the figure by a gaseous hydrobromic acid generator 16. 65

In these conditions, the specific laser power is 1 to 2 kW for a molecular hydrogen discharge of 1 mole/second.

The electric efficiency (quotient of laser energy divided by excitation energy) is about 10%.

The method in accordance with the invention can be applied to producing lasers for range finding and for space telecommunications.

CLAIMS

1. A method of generating a laser beam with a wavelength of 2.71 microns, said method consisting in:
 - 10 —forming hydrogen atoms in an initial gas which includes molecular hydrogen by setting up a high tension electric discharge therein, said discharge also producing vibrationally excited molecular hydrogen;
 - expanding the gas which contains the hydrogen atoms by passing it through the nozzles at supersonic speed;
 - 15 —injecting gaseous hydrobromic acid at the outlet of the nozzles in the gas flow direction, said acid reacting with the atomic hydrogen to form bromine atoms at quantum level $2P_{3/2}$ together with vibrationally excited molecular hydrogen in addition to that formed by the electric discharge, thereby increasing the quantity of excited molecular hydrogen which then transfers its excitation energy to the bromine so as to excite the bromine atoms at level $2P_{1/2}$; and
 - 20 —making the gas which leaves the nozzles and which contains bromine atoms at level $2P_{1/2}$ pass through an optical resonant cavity perpendicularly to the axis of the cavity to obtain a continuous laser beam with a wavelength of 2.7 microns at the output of the cavity.
 2. A method according to claim 1, wherein the ratio between the electric field of the discharge and the pressure of the gas which is subjected to said discharge lies between 2 and 25 V/cm X torr.
 3. A method according to claim 1, wherein the gas expands sufficiently for the temperature of the expanded gas to be less than 300°K.
 4. A method according to claim 1, wherein the initial gas is pure hydrogen.
 5. A method according to claim 1, wherein the initial gas is a mixture of molecular hydrogen 30 and an inert gas.
 6. A method according to claim 1, wherein the discharge is set up longitudinally inside a tube disposed upstream from each nozzle.
 7. A method of generating a laser beam with a wavelength of 2.71 microns, substantially as herein described with reference to the accompanying drawing.

CLAIMS

Superseded claim 1

New or amended claim 1

1. A method of generating a laser beam with a wavelength of 2.71 microns, said method consisting in:
 - 40 —forming hydrogen atoms in an initial gas which includes molecular hydrogen by setting up a high tension electric discharge therein, said discharge also producing vibrationally excited molecular hydrogen;
 - expanding the gas which contains the hydrogen atoms by passing it through the nozzles at 45 supersonic speed;
 - injecting gaseous hydrobromic acid at the outlet of the nozzles in the gas flow direction, said acid reacting with the atomic hydrogen to form bromine atoms at quantum level $2P_{3/2}$ together with vibrationally excited molecular hydrogen in addition to that formed by the electric discharge, thereby increasing the quantity of excited molecular hydrogen which then transfers its 50 excitation energy to the bromine so as to excite the bromine atoms at level $2P_{1/2}$; and
 - making the gas which leaves the nozzles and which contains bromine atoms at level $2P_{1/2}$ pass through an optical resonant cavity perpendicularly to the axis of the cavity to obtain a continuous laser beam with a wavelength of 2.71 microns at the output of the cavity.